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Brain Controlled Artificial Legs by Using Electrode Cap.

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ABSTRACT

This paper describes a brain controlled robotic leg which is designed to perform the normal operations of a human leg. After implanting this leg I n a human, the leg can be controlled with the help of user's brain signals alone. This leg behaves similar to a normal human leg and it can perform operation like walking, running, climbing stairs etc. The entire system is controlled with the help of advanced microcontrollers and digital signal processors. The signals are taken out from the human brain with the help of electroencephalography technique. The person can perform operations like walking, running etc just by their thought. This system will be very much suitable for those who lost their legs in accidents and the proposed system is hundred percent feasible in the real time environment with the currently available technology. The Brain Controlled Artificial Legs are very much cost effective when compared to the normal Artificial legs which is available in the market. The reduction in cost of the proposed system is found to be above 80% when compared to the existing system. Moreover, the user can have full control over the artificial legs which is not possible in the existing system.

Keywords: brain, artificial leg, electrode cap.

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INTRODUCTION

A brain-computer interface (BCI), some-times known as an instantaneous neural interface or a brain-machine interface, could be a direct communication path-way between a personality's or ANimal brain and an ex-ternal device. during this definition, the word brain means that the brain or system nervous of AN organic structure instead of the mind. laptop means that any process or machine device, from simple circuits to the complicated microprocessors and microcontrollers.

An interesting question for the event of a BCI is the way to handle 2 learning systems: The machine ought to learn to discriminate between completely different patterns of brain activity as correct as potential and also the user of the BCI ought to learn to perform different mental tasks so as to supply distinct brain sig-nals. BCI analysis makes high demands on the system and software system used. Parameter extraction, pattern recognition and classification area unit the most tasks to be performed in an exceedingly brain signals. during this paper it's assumed that the user of this method has one leg that is functioning absolutely and also the sys-tem is meant consequently. this method will be extended for each the legs and it's not restricted to the funda-mental operation of human legs reminiscent of walking, running, rising stairs etc. It may perform operations like athletics, hopping etc

EXISTING SYSTEM

Brain Waves

Electrical activity emanating from the brain is displayed within the type of brainwaves. There ar four classes of those brainwaves starting from the foremost activity to the smallest amount activity. once the brain is aroused and actively engaged in mental ac-tivities, it generates beta waves. These beta waves ar of compara-tively low amplitude, and ar the quickest of the four completely different brainwaves. The frequency of beta waves ranges from fifteen to forty cycles a second. succeeding brainwave class so as of frequency is Alpha. wherever beta diagrammatical arousal, alpha represents non-arousal. Alpha brainwaves ar slow-er and better in amplitude. Their frequency ranges from nine to fourteen cycles per second. succeeding state, the-ta brain-waves, is often of even bigger ampli-tude and slower frequency. This frequency vary is often between five and eight cycles a second. A per-son United Nations agency has taken day off from a task and begins to daydream is commonly in a very alphabetic character brainwave state. the ultimate brainwave state is delta. Here the brain-waves ar of the best amplitude and slowest frequency. They usually focus on a spread of one.5 to four cycles per second. They ne'er go all the way down to zero as a result of that will mean that you simply were dead. But, deep untroubled sleep would take you all the way down to the bottom frequency. Typically, two to three cycles a second.

In the proposed system alpha waves and beta waves are used from the brain for signal processing. It is assumed that the person is in alpha state and beta state (which is the case normally) and these waves are taken out from the human brain and converted in the form of electrical signals with the help of electrode caps. The following figure shows the different types of waves and also the mental state of the person. Those waves usual-ly vary from a frequency of 1Hz to 40 HZ.

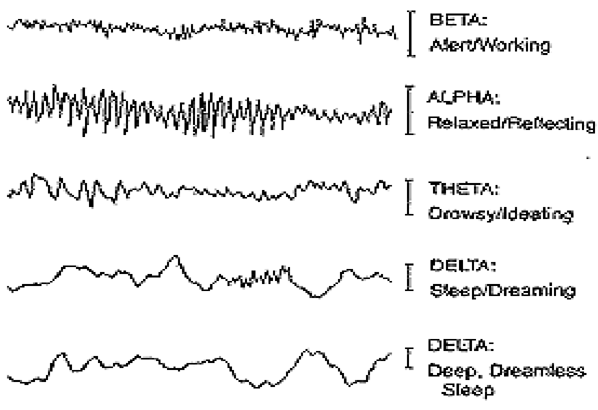

Fig 1: Different Types of Brain Waves

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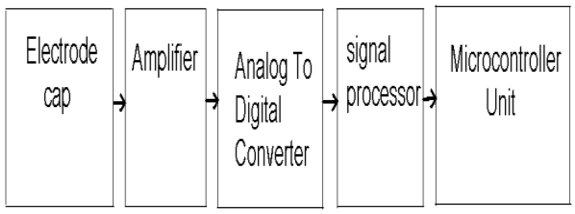

Fig 2: General Block Diagram of the System

Fig 2 shows the final diagram of the planned system. Conductor cap is placed within the scalp of the person. The signals taken out from the human brain are going to be within the vary of mV and µV. thus they're fed to AN electronic equipment. Then it's sent to a Analog to Digital convertor to convert the analog brain signals in to digital kind. Then it's sent to a sign processor wherever parameter extraction, pattern classification and pattern identification square measure done. These digital signals square measure fed as input to microcontroller unit. The last four units (Amplifier, Signal Processor, Analog to Digital convertor and Microcontroller Unit) square measure placed within the artificial leg. The output of the microcontroller unit is fed to the driving circuit. allow us to see regarding these blocks thoroughly.

Electrode Cap

Fig 3 shows an individual carrying AN conductor cap. These conductor caps contains electrodes that area unit placed on the bone in a briefing referred to as 10-20 system, a placement theme devised by the international federation of societies of graph. In most applications nineteen electrodes area unit placed within the scalp. Additional electrodes is supplementary to the quality set-up once a clinical or analysis application demands enlarged spacial resolution for a selected space of the brain. High-density arrays (typically via cap or net) will contain up to 256 electrodes more-or-less equally spaced round the scalp. the most perform of the conductor cap is to require the brain signals within the kind of electrical signals. The signals taken out from the conductor cap area unit fed to AN electronic equipment.

Fig 3: A person wearing electrode cap

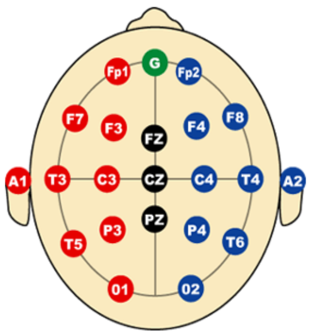

Fig 4: Placement of electrodes in 10-20 system

Amplifier

The signal from the conductor cap are within the vary of mV and µV. So, these signals won't be appropriate for signal process. thus these signals area unit fed to Associate in Nursing electronic equipment. every conductor is connected to at least one input of a differential electronic equipment (one electronic equipment per try of conductors); a typical system reference electrode is connected to the opposite input of every differential electronic equipment. These amplifiers am-plify the voltage between the active conductor and also the reference (typically one,2000–100,000 times, or 60–100 dB of voltage gain).

Analog to Digital Converter

The output signals from the electronic equipment are analog in nature. They additionally contain some unwanted signals. therefore the output signals are filtered mistreatment high pass and low pass filters. The high-pass filter typi-cally filters out slow unit whereas the low-pass filter filters out high-frequency artifacts. when the signal is filtered they can't be directly fed to a digital signal processors and microcontroller unit as they're in analog kind. therefore these signals are sent to associate Analog to Digital convertor to convert the incoming analog signals in to digital signals.

Signal Processor

Using the output signal from the A/D converter, parameter extraction, pattern classification and pattern identification are done. Then the signals are fed to a Fast Fourier Transform Unit. This is done to simplify the calculations. An FFT algorithm computes the result in O ($N \log N$) operations instead of O (N^2) operations. The output signals from the signal processor are fed to a Microcontroller unit.

Microcontroller unit

The output signals from the signal processor square measure fed to a microcontroller unit.This microcontroller unit performs the robotic operation with the assistance of a stepper motor. it'll management the operations cherish walking, running, etc relying upon the signal. for various patterns of input signals it'll be pre-programmed to try and do a particular opera-tion. The reference signal are already hold on within the microcontroller memory in digital kind. typically associate degree eight bit or a sixteen bit microcontroller is most popular de-pending upon the quantity of operations to be per-formed. The complexness of the microcontroller programming will increase with the quantity of operation that should be performed.

Working of the Proposed System

For every act the brain waves changes its pattern. let's say, if an individual moves his/her hands then a selected pattern of brain wave is obtained and if a similar person moves his/her legs then a unique pattern of brain wave is obtained. Although an individual thinks of moving his/her legs a brain wave of specific pattern is made and it's sent to the legs and so the operation of moving the legs is performed. a similar brain waves square measure made even for an individual WHO isn't having his/her legs. however the operation of moving the legs won't be performed thanks to the absence of legs. So, simply by thinking of moving the legs, a brain wave that is capable of playacting a selected op-eration is generated within the brain. thanks to the dearth of the suitable system, the activity won't be per-formed with success, within the planned system, the brain waves square measure pre-recorded for every operation to be performed and these waves square measure used as reference signals. These signals square measure hold on within the microcontroller memory. for every reference signal within the microcontroller memory, the robotic leg is pre-programmed to try and do a selected operation. once the reference sig-nal matches with the particular signal from the user's brain, the robotic leg can do the pre-programmed operation with the assistance of the microcontroller.

For example, allow us to say that the user is thinking of walking. Therefore a brain wave are going to be made. These waves square measure processed and so it's reborn in to digital signals. These signals square measure compared with the pre-recorded reference signals and a match within the signal pattern are going to be found within the microcontroller. The operation for this explicit pre-recorded signal are going to be pre-programmed within the microcontroller circuit i.e. walking and so the microcontroller can send the management signal to the factitious robotic leg and therefore the robotic leg can perform the specified operation. Typically a stepper motor controlled robotic leg is employed for this purpose. Equally to walking, alternative opera-tions can even be performed victimization the factitious leg. This method is extremely user friendly and there-fore the system may be designed in step with the user's needs i.e. the quantity of operations needed for the user may be mounted by him and therefore the system may be designed consequently. Therefore the range of opera-tions that must be performed by the leg may be raised or diminished and therefore the complexness of the planning varies consequently.

This idea may be extended for each the legs and each the legs may be created to try to to operations like walk, run etc at the same time. so the system is flexible. this method is hundred p.c possible within the real time atmosphere and it may be established to any human regardless of their age.
Figure 5, 6, 7, 8, 9 and 10 shows some of the pictures of artificial legs.

Fig 5: Proposed Model of the artificial legs

Fig 6: Internal appearance of the artificial leg.

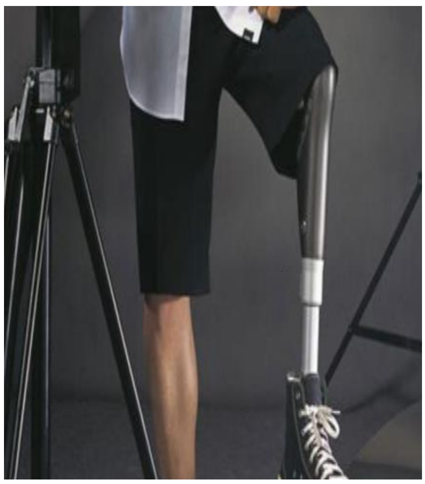

Fig 7: External Appearance of the artificial leg

Fig 8: Walking down the stairs using artificial

Fig 9: Artificial legs fitted to both the limbs

Fig 10: Walking with artificial legs.

Power Supply

These artificial legs are powered by a small lithium-ion battery which has to be charged once in 2 day. Lithium-ion batteries have very high charge density (i.e. a light battery will store a lot of energy). They are of ultra-slim design and hence they occupy very less space. Moreover their life time will be longer when compared to other batteries. Hence they are preferred when compared to other batteries. Moreover they have longer life time when compared to other batteries.

Normal Artificial legs

Normal Artificial Legs, available in the market, is very costly. They use a group of sensors and a complex algorithm for their operation which makes the existing system very costly. This disadvantage has been overcome in the Brain Controlled Artificial Legs as they don't use any sensors for their operation. Moreover the normal artificial legs are 100% dynamic in operation. Hence the chance of occurrence of an error is more in those systems. External appearance and output of both the legs are same. But the method of operation is different. Hence the Brain Controlled Artificial Legs are cost effective.

Difference between the Brain Controlled Artificial legs and the Normal Artificial Legs:

Brain Controlled Artificial Legs	Normal Artificial Legs
1. Ease of Construction	1. Complex in construction
2. Cost is not more than Rs.5,00,000	2. Cost is about \$80,000-\$90,000(Rs.35,00,000 to Rs.40,00,000)
3. User can have full control over the artificial leg.	3. User cannot have full control over the artificial leg.
4. Semi-Automatic	4. Fully Automatic
5. Sensors are absent.	5.Sensors are present
6. Requires simple control unit.	6. Requires complex control unit.

CONCLUSION

Forty years ago, the technology was so basic. Newton said. "Leg sockets were made out of wood, offering the equivalent of a door hinge at the knee". But with the recent advancement in the technology, Brain Controlled Artificial leg can be made as a reality. The performance of the proposed system will be better than the existing artificial legs as the user has full control over the Brain Controlled Artificial Legs. Hence it behaves like a normal human leg. The built-in battery lasts anywhere from 25 to 40 hours so it can support a full day's activity. The recharge can be performed overnight or while traveling in a car via a cigarette lighter adapter.

The cost of the proposed system is found to be very less when compared to the existing ones. So, even the middle class people who cannot purchase the existing artificial legs can make use of this proposed system. With this system life can be made easier for the handicapped persons and they can also do their day-to-day activities normally without any difficulties [1-19].

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